EVM User's Guide: ADC32RF55EVM, TRF1305EVM

TRF1305-ADC32RFEVM Evaluation Module

Description

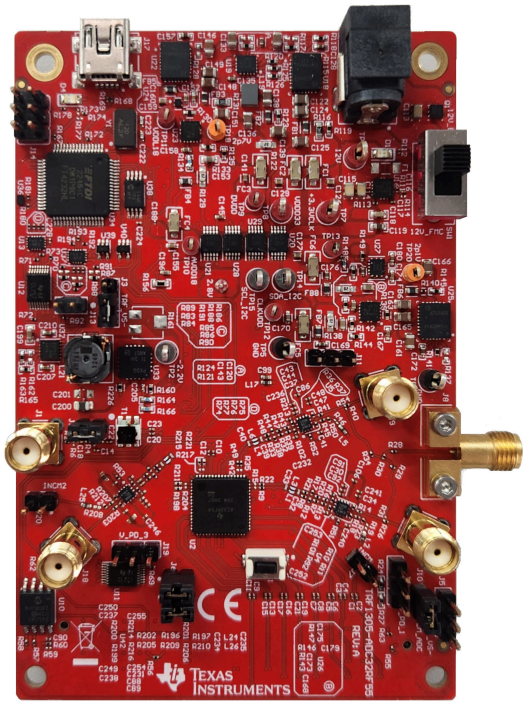
The TRF1305-ADC32RFEVM is an evaluation module (EVM) designed to evaluate the ADC32RF5x family of high-speed, JESD204B-interface ADC paired with the TRF1305 fully-differential RF amplifier. The EVM also includes an onboard clocking design (LMK04832), DC power distribution, and an easy-to-use software GUI and USB interface.

Features

- An input channel featuring TI's fully-differential RF amplifier TRF1305 allowing a single-ended signal input with bandwidth from DC-2 GHz.
- An input channel featuring dual TRF1305 devices in a noise reduction scheme.
- LMK04832 system clock generator that generates field-programmable gate array (FPGA) reference clocks for the high-speed serial interface.
- Flexible linked common mode operation enabled by the TRF1305 allowing full use of dynamic range of ADC and DC operation.

Applications

- Phased array radar
- Spectrum analyzer
- Software defined radio (SDR)
- Electronic warfare
- High-speed digitizer
- Cable infrastructure
- Communications infrastructure



EVM

1 Evaluation Module Overview

1.1 Introduction

This document is the user's guide for the TRF1305-ADC32RFEVM evaluation module. This user's guide provides the schematic, bill of materials, and board layout of the EVM. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TRF1305-ADC32RFEVM.

1.2 Kit Contents

The following is included in the EVM evaluation kit:

- TRF1305-ADC32RFEVM evaluation board
- Power supply cable
- USB 2.0 Type-A to mini-B cable

1.3 Specification

The TRF1305B1 is a very high performance, closed-loop, dual-channel RF amplifier that has an operational bandwidth from true-dc to > 6.5GHz.

The ADC32RF5x is a single core 14-bit, 2.6 GSPS to 3 GSPS, dual channel analog to digital converters (ADC) that supports RF sampling with input frequencies up to 3GHz.

1.4 Device Information

The TRF1305-ADC32RFEVM is designed to work seamlessly with TI's TSW14J58 EVM JESD204B and JESD204C data capture and pattern generator card, through the High Speed Data Converter Pro (HSDC Pro) software tool for high-speed data converter evaluation. The TRF1305-ADC32RFEVM is also designed to work with many of the developments kits from leading FPGA vendors that contain an FMC or FMC+ connector.

2 Hardware

2.1 Required Hardware

The following list of equipment are items that are **not included** in the EVM evaluation kit, but are required items (to achieve the best performance) for the evaluation of this product:

- TSW14J58 EVM data capture board
- 6V, 5A power supply
- 12V, 2A power supply
- USB 2.0 Type-A to mini-B cable
- USB 3.0 Type-A to micro-B cable (qty. 2)
- Low-noise signal generator (qty. 2) (examples: HP HP8644B, Rohde & Schwarz SMA100A)
- Bandpass filter for clock input
- Bandpass filter for desired analog input
- High quality signal path cables

2.2 Required Software

The following software is required to operate the TRF1305-ADC32RFEVM and is available online. For related links, see Section 6.

- ADC32RF5x EVM GUI

The following software is required to operate the TSW14J58 EVM and is available online. For related links, see Section 6.

- High Speed Data Converter Pro, version 5.2 or higher

3 Quick Start Guide

The EVM test procedure to obtain a valid data capture from the TRF1305-ADC32RFEVM using the TSW14J58EVM data capture board is provided in this section. This is the starting point for all evaluations.

3.1 Introduction

The TRF1305-ADC32RFEVM includes the ADC32RF5x analog-to-digital converter with JESD204B interface, three TRF1305 RF differential amplifiers, the LMK04832 clocking chip, and an FMC connector designed for connection to the readily-available FPGA development boards or to the TSW14J58EVM data capture board.

The FPGA on the capture card requires a device clock and SYSREF signal, the LMK04832 clock device supplies these signals to the FMC connector for that purpose, as well as supplying SYSREF to the ADC.

This document conveys all information needed to bring up both the TRF1305-ADC32RFEVM and TSW14J58EVM data capture board, and get a valid data capture with good FFT results.

The JESD204B interface requires a number of important parameters to be decided in advance of setting up the data link, such as; number of lanes, number of converters, number of samples per frame, and a value K number of frames per multi-frame, among other parameters. Both sides of a JESD204B link must be set up with the same values for all these parameters, or else the FPGA that receives the data is not able to establish a synchronized link.

Note

Getting these parameters inconsistent between ADC and FPGA is perhaps the biggest single reason for an EVM setup to not function as expected.

The GUI installers that come with the ADC32RF5x and the TSW14J58EVM come with configuration files that are meant to enable quick initial setup of a number of basic configurations. TI **strongly** recommends setting up the EVM and data capture board with a configuration described in this document and getting a working setup before modifying the configuration to be closer to what the end-application requires. In this way, users can know that the hardware is functioning and that there is a working configuration that users can go back to in the event of difficulty developing the configuration.

This document introduces the software that must be installed on a PC, and presents a basic setup for the Bypass and DDC modes available in the TRF1305-ADC32RFEVM. The operating modes explained in this document are:

- Bypass Mode
  - 2x averaging
- DDC (decimation)
  - 8x complex decimation
  - 128x complex decimation

3.2 Hardware Setup

A typical test setup using the TRF1305-ADC32RFEVM and TSW14J58EVM is shown in Figure 3-1.

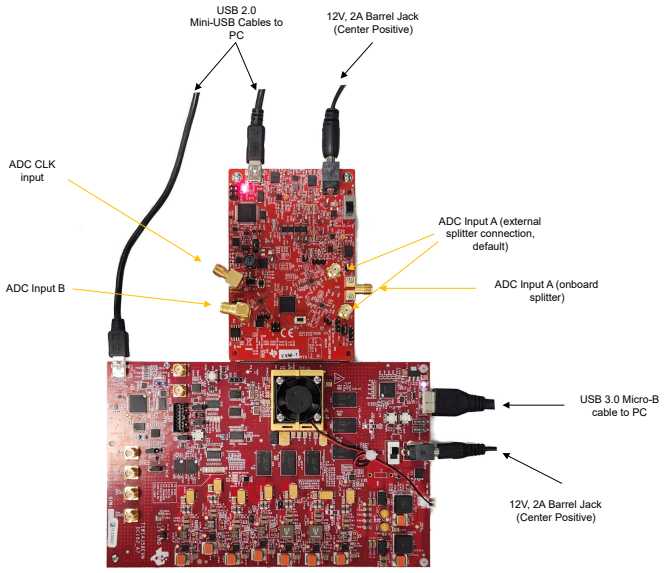


Figure 3-1. TRF1305-ADC32RFEVM Bench Setup Block Diagram

The jumper settings to enable the RF amplifiers and capture data are shown below.

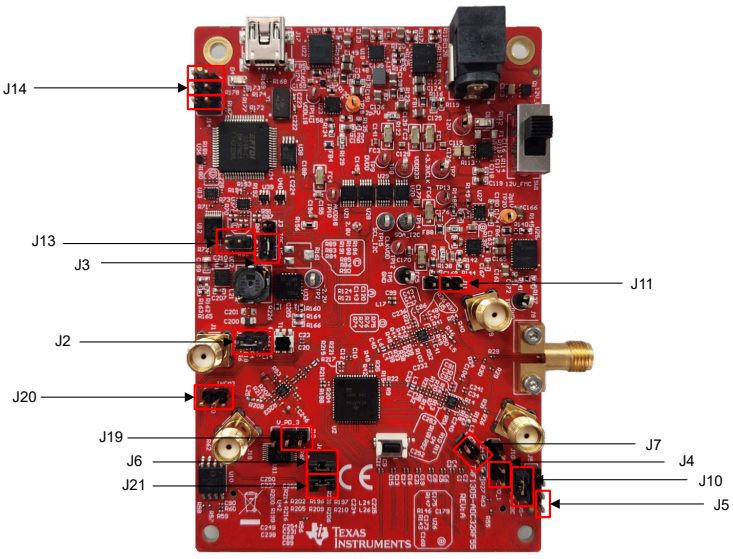


Figure 3-2. Jumper Locations

Table 3-1. Jumper Settings

Jumper	Silkscreen Label	Channel	Description
J2	J2	A	Installed (default): Positive supply connection to +2.8V for all TRF1305 devices.
J3	TRF_VS-	A	Installed (default): Negative supply connection to -2.2V for all TRF1305 devices.
J4	V_PD_1	A1	Uninstalled (default): Power down signal connection to low, enabling TRF1305. When left floating, powers up the TRF1305.
J5	SCL TRF_VS-	A, B	Uninstalled (default): Thermal pad electrical connection for all TRF1305 devices to negative supply.
J6	J6	A	Installed (default): TRF1305 connection to ADC common mode voltage.
J7	INCM	A	Uninstalled (default): Connection of TRF1305 INM pin to GND, allowing single-ended input. This connection is made on the PCB.
J10	VCM_ADC	A	Installed (default): TRF1305 connection to ADC common mode voltage.
J11	J11	A2	Uninstalled (default): Powerdown signal connection to low, enabling TRF1305. When left floating, powers up the TRF1305.
J13	J13	N/A	Uninstalled (default): Serial source selection set to onboard FTDI.
J14	J14	N/A	Uninstalled (default): FMC and USB control of ADC enabled.
J19	V_PD_3	B	Uninstalled (default): Power down signal connection to low, enabling TRF1305. When left floating, powers up the TRF1305.
J20	INCM2	B	Uninstalled (default): Connection of TRF1305 INM pin to GND, allowing single-ended input. This connection is made on the PCB.
J21	J21	B	Installed (default): TRF1305 connection to ADC common mode voltage.

3.3 Software Setup

The proper software must be installed before beginning evaluation. For a list of the required software, see Section 2.2. To avoid potential issues, the software needs to be installed before connecting the TRF1305-ADC32RFEVM and TSW14J58EVM to the computer for the first time. The links for the software on ti.com are shown in Section 6.

3.3.1 ADC32RF5xEVM GUI Installation

1. Download the GUI installer from the EVM tool folder at https://www.ti.com/tool/ADC32RF54EVM
2. Extract the installation files from the downloaded zip file.
3. Run *TI-ADC32RF5x.exe* and follow the procedure of the installer to complete installation.

3.3.2 High Speed Data Converter Pro GUI Installation

High Speed Data Converter Pro GUI (HSDC Pro) is used to control the TSW14J58EVM and analyze the captured data. Please see the High Speed Data Converter Pro GUI user's guide for more information.

1. Download HSDC Pro GUI installer.
2. Extract the installation files from the downloaded zip file.
3. Run *setup.exe* and follow the installation prompts to complete installation.

3.4 Quick Start Procedure for Bypass Mode

Bypass mode is the default operating mode for the ADC32RF5x device family. When operating in this mode, the digital decimation filters that the ADC32RF5x offers is bypassed. Additionally, the user has the option to enable averaging of each internal pair of ADCs per individual channel. Operating in bypass mode without averaging provides the lowest power consumption for ADC32RF5x devices.

TSW14J58EVM

1. Connect the TRF1305-ADC32RFEVM to the TSW14J58EVM using the FMC connectors.
2. Connect a 6V, 5A minimum power supply to connector J2.
3. Connect a USB 2.0 Type-A to Mini-B cable to connector J23.
4. Connect a USB 3.0 Type-A to micro-B cable to connector J1.
5. Turn on the power supply and toggle the power switch (SW5) to the *ON* position. The fan starts spinning and the current draw settles at approximately 2.1A.

TRF1305-ADC32RFEVM

1. Connect a 12V, 2A minimum power supply to the connector J11.
2. Connect a USB 2.0 Type-A to mini-B cable to connector J12.
3. Make sure jumper settings are as detailed in Table 3-1.
4. Connect a filtered 2.56GHz clock signal (**+10 dBm**) to input J1 (EXTCLK), then enable the signal generator output.
5. Connect a filtered 300MHz input signal (**-20 dBm**) to input J8 (INA), then enable the signal generator output.

GUI Setup

1. Open High Speed Data Converter Pro (HSDC Pro) and select the TSW14J58. If no device is found, verify that power is on and both USB cables are connected.
2. Select the device firmware labeled **ADC32RF5x_8224_12G-16G** and update the firmware by pressing **Yes** on the pop-up window and waiting for the *Downloading Firmware* message to finish.
3. Enter *2.56 G* into the ADC Output Data Rate field. A message appears stating *New lane rate is 12.8G due to ADC Output Data Rate change*. When this appears, press *OK*.
4. Enter *300M* into the ADC Input Target Frequency field and tick the checkbox *Auto Calculation of Coherent Frequencies*. Notice that the 300M changes to 300.039M.
5. Open the ADC32RF5x GUI. Verify that the green USB Status indicator is illuminated as shown in Figure 3-3. If the indicator is red (simulation mode), then verify that the USB cable is connected and that the TRF1305-ADC32RFEVM is powered on and press the *Reconnect USB* button.

Figure 3-3. USB Status Indicator

3.4.1 2x Averaging in Bypass Mode

This mode uses internal averaging to provide better noise performance at the tradeoff of higher power consumption and frequency response flatness.

Procedure

1. In the bypass mode box of the GUI, make sure that the settings match those shown in Figure 3-4.

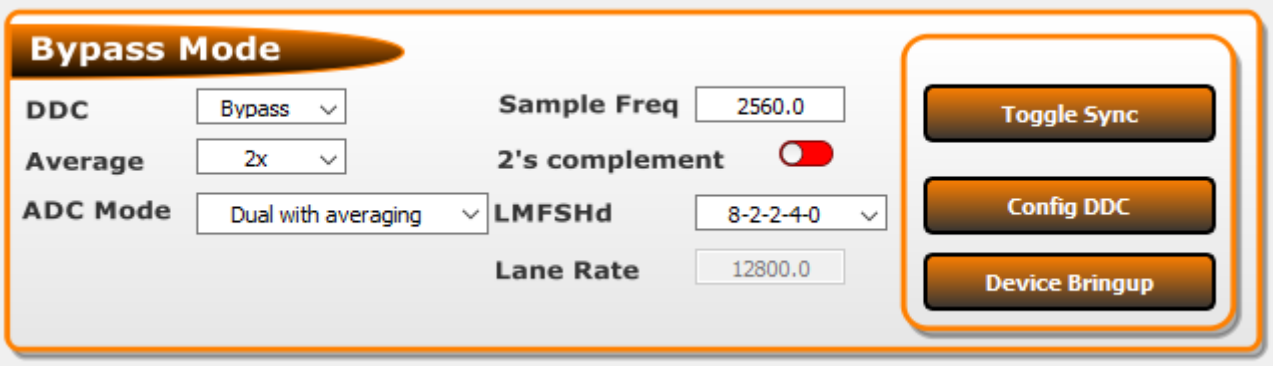


Figure 3-4. Bypass Mode Settings

2. Once these settings are verified, press the *Device Bringup* button.
3. Wait until after the message *Device Bringup Completed* appears in the Log.
4. Under the *Analog and Clock* tab, toggle *Dither Enable* to the *off* position.
5. In HSDC Pro, press the *Capture* button. A screen appears, similar to Figure 3-5.
6. Adjust signal generator output such that the measured fundamental power in HSDC Pro is at the user's desired level. (shown below is -12 dBFs)

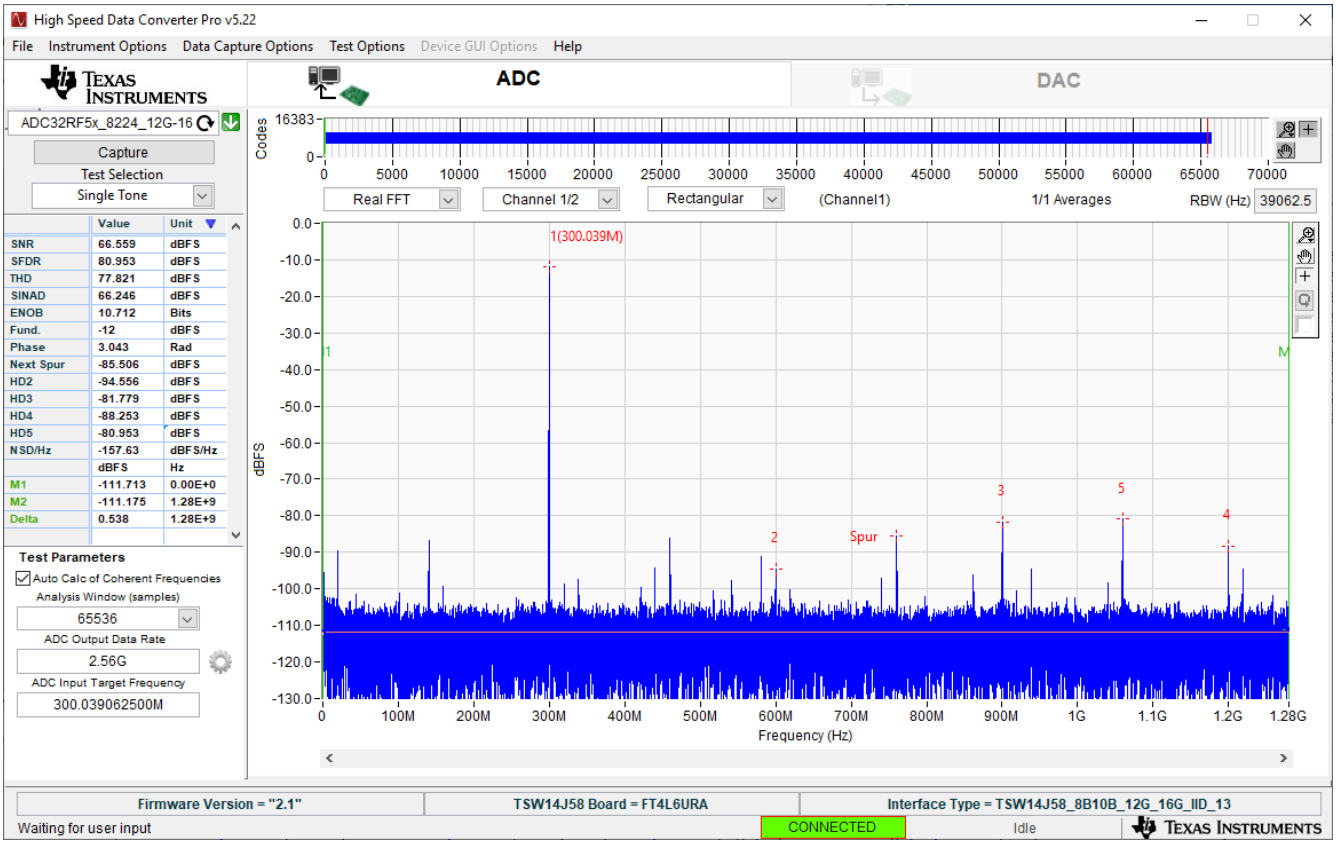


Figure 3-5. 300.039MHz, bypass mode, 2x averaging, dither off

3.5 Quick Start Procedure for Complex Decimation Mode

The ADC32RF5x device family provides up to two digital down converters (DDC) per ADC channel supporting a wide range of instantaneous bandwidth IBW coverage - from single wide band mode with 8x complex decimation to up to two narrow band channels with as high as 128x complex decimation.

When operating in complex decimation mode, the appropriate NCO is used as an intermediate frequency to the complex mixer. Similar to the bypass operating mode, the user has the option to enable averaging of each internal pair of ADCs. This section provides two example configurations for operating the TRF1305-ADC32RFEVM in 8x and 128x decimation modes.

3.5.1 8x Complex Decimation

This example uses a coherent 790MHz input on the channel A input with the ADC in a 1x averaging mode with dither enabled.

Procedure

1. In the *Bypass Mode* box, use the DDC drop-down to change to *Complex Mode*. Notice the box title changes to *Complex Mode* to reflect the current DDC operating mode.
2. Use the *Decimation* drop-down to change the decimation to *8*.
3. Set the *LMFSHd* setting to *4-4-2-1-0.*
4. Set the channel INA1 *NCO0* and *NCO1* to 800 (MHz).
5. Change *LMK divider* from 8 to 16.
6. Once these settings are verified and match Figure 3-6, press the *Device Bringup* button.

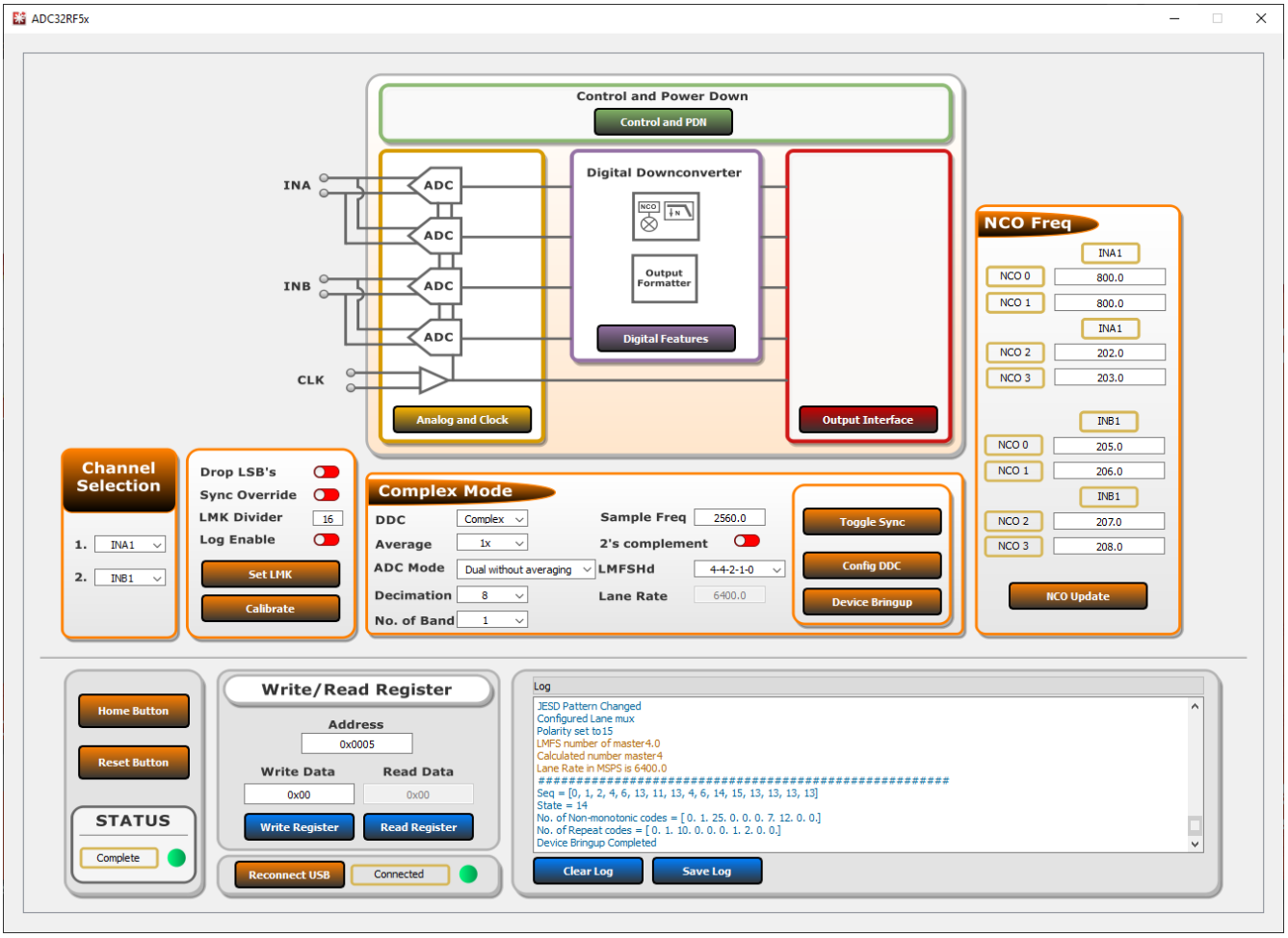


Figure 3-6. ADC32RF5xEVM GUI, 8x Complex Decimation, 800MHz NCO

7. Wait until after the message *Device Bringup Completed* appears in the Log.

8. In HSDC Pro, connect to the TSW14J58EVM and select *ADC32RF5x_4421_6G-8G* as the INI file shown in Figure 3-7.

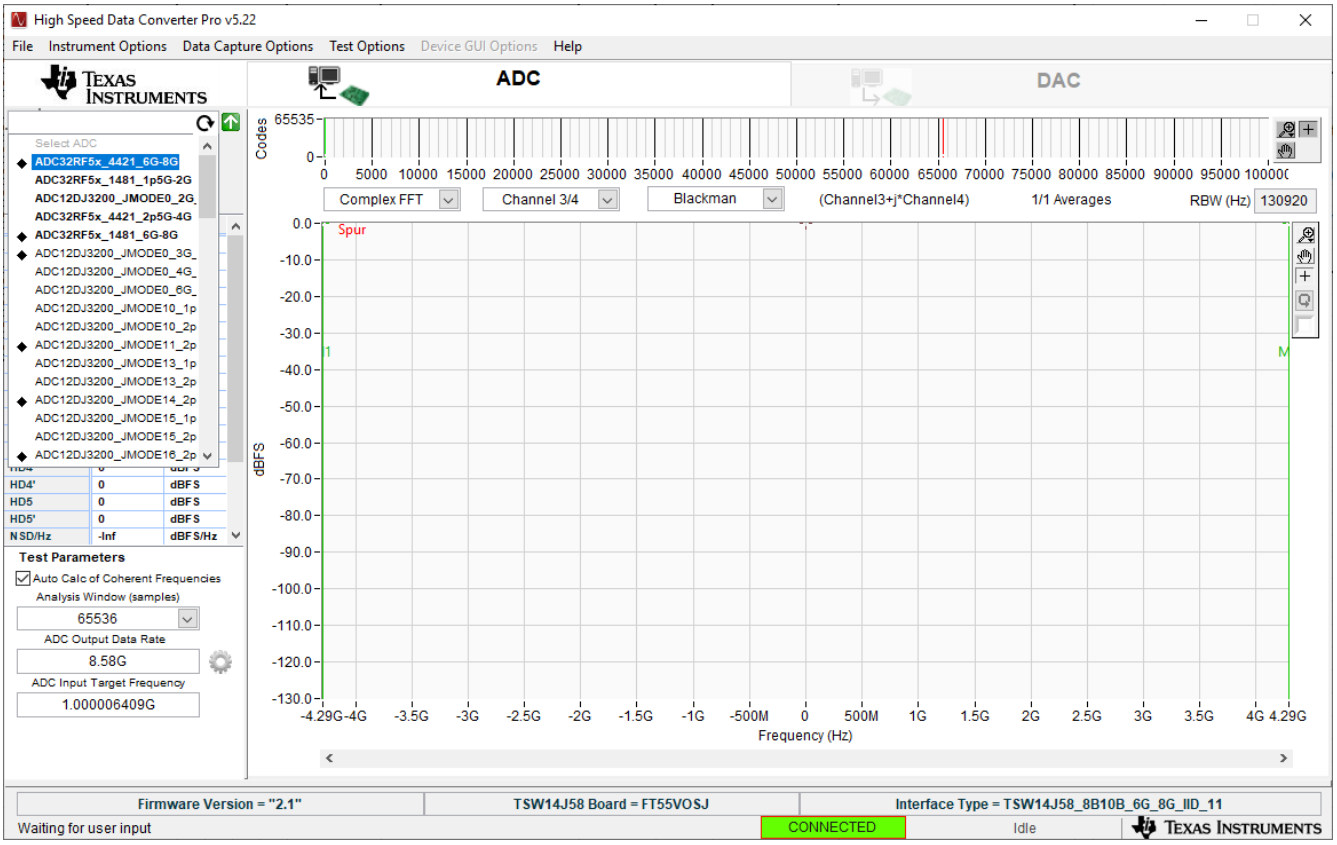


Figure 3-7. ADC32RF5x_4421_6G-8G INI file

9. Update the firmware by pressing *Yes* on the pop-up window and waiting for the *Downloading Firmware* message to finish.
10. Open the Additional Device Parameters menu by clicking on the gear next to the ADC Output Data Rate field.
11. Check the box labeled *Enable?* and then enter the parameters shown in Figure 3-8.

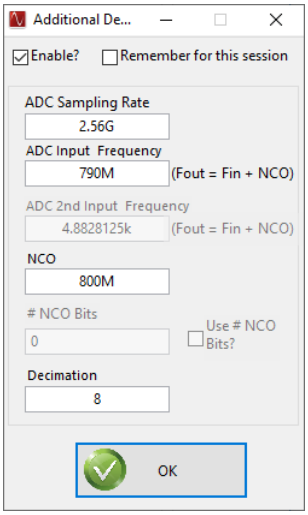


Figure 3-8. Additional Device Parameters , 8x complex decimation

12. Once completed, click *OK*.
13. Check the box labeled *Auto Calculation of Coherent Frequencies* to see the *ADC Input Target Frequency* change from 790M to the coherent frequency. Set the signal generator connected to channel A input to this coherent frequency.

14. Change the view window from *Real FFT* to *Complex FFT* and select channel 1/4.
15. Press the *Capture* button and a screen similar to Figure 3-9 pops up.
16. Adjust signal generator output such that the measured fundamental power in HSDC Pro is at the user's desired level.

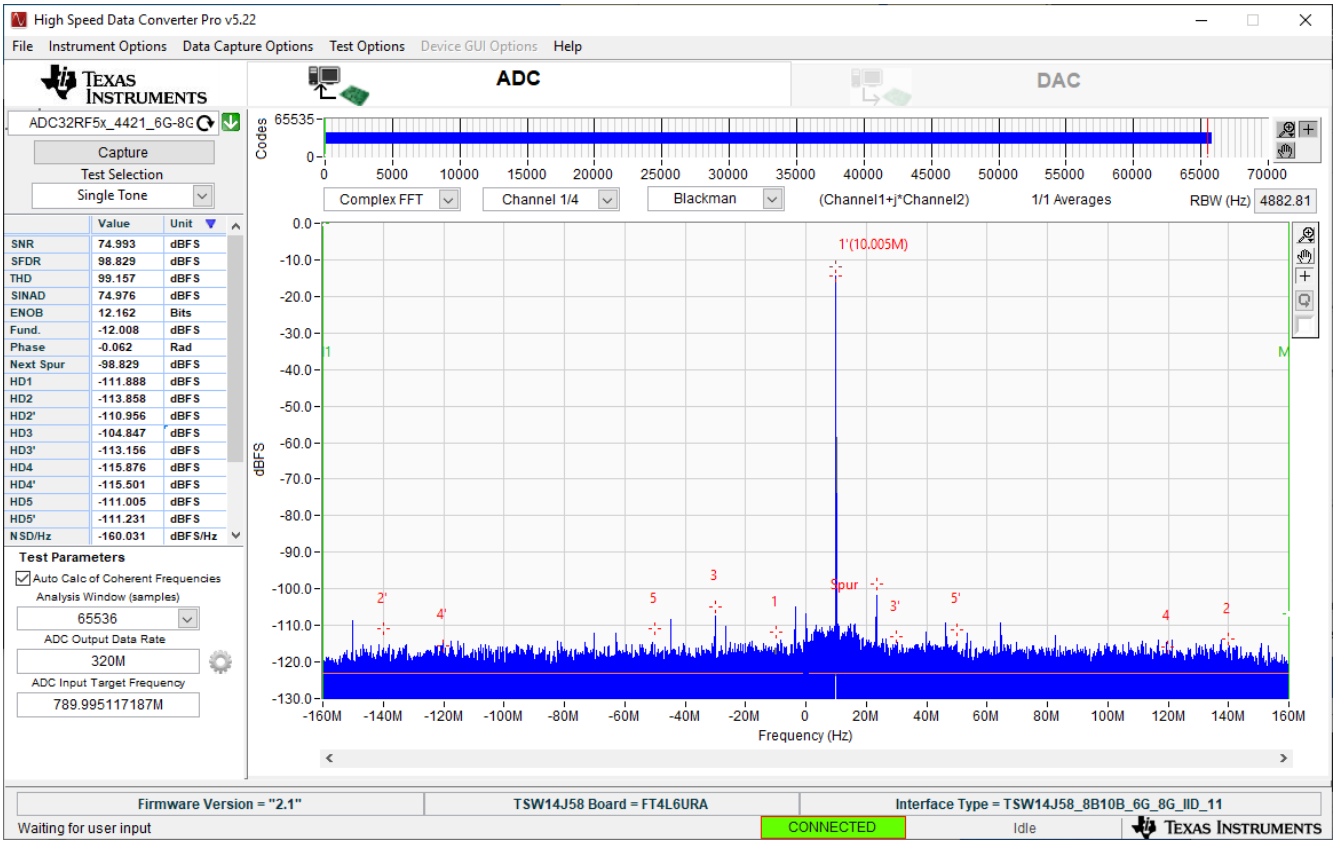


Figure 3-9. 789.995MHz Input, 8x Complex Decimation, 1x Averaging, Dither On

3.5.2 128x Complex Decimation

This example uses a coherent 1.003GHz input on the channel B input with the ADC in a 2x averaging mode with dither enabled.

Procedure

1. Under the *Analog and Clock* tab, toggle *Dither Enable* to the on position and set *Dither Amplitude_1* to 3.
2. In the *Bypass Mode* box, use the DDC drop-down to change to *Complex Mode*. Notice that the box title changes to *Complex Mode* to reflect the current DDC operating mode. Press the *Home Button* to change back to the home screen.
3. Set *Average* to *2x* and change *ADC Mode* to *Dual with averaging*.
4. Use the *Decimation* drop-down to change the decimation to *128*.
5. Set the *LMFSHd* setting to *1-4-8-1-0.*
6. Set the channel INB1 **NCO0** and **NCO1** to 1000 (MHz).
7. Change *LMK divider* from 8 to 32.
8. Once these settings are verified and match Figure 3-10, press the *Device Bringup* button.

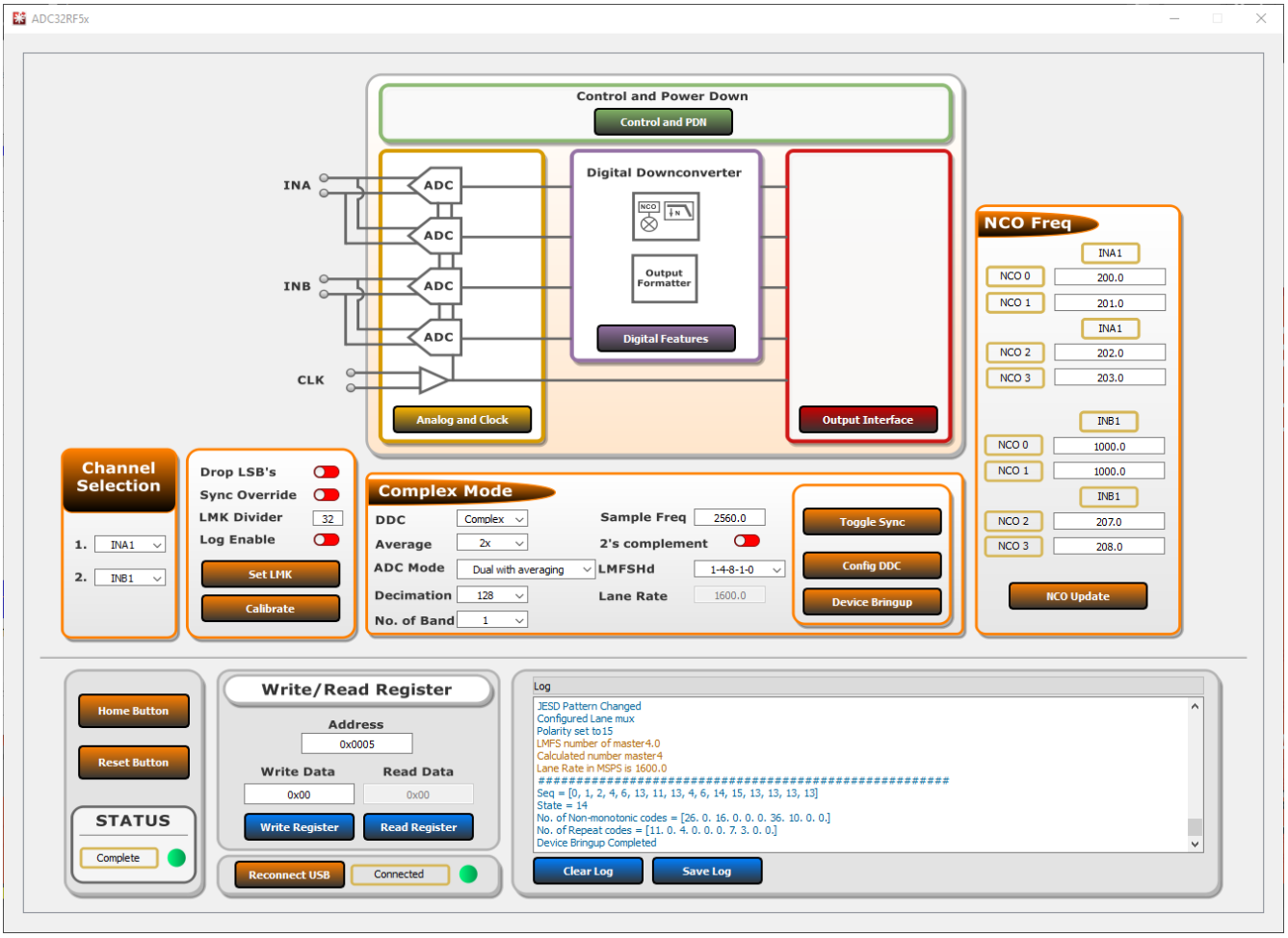


Figure 3-10. ADC32RF5xEVM GUI, 128x complex decimation, 1GHz NCO

9. Wait until after the message *Device Bringup Completed* appears in the Log.
10. In HSDC Pro, connect to the TSW14J58EVM and select *ADC32RF5x_1481_1p5G-2G* as the INI file shown in Figure 3-11.

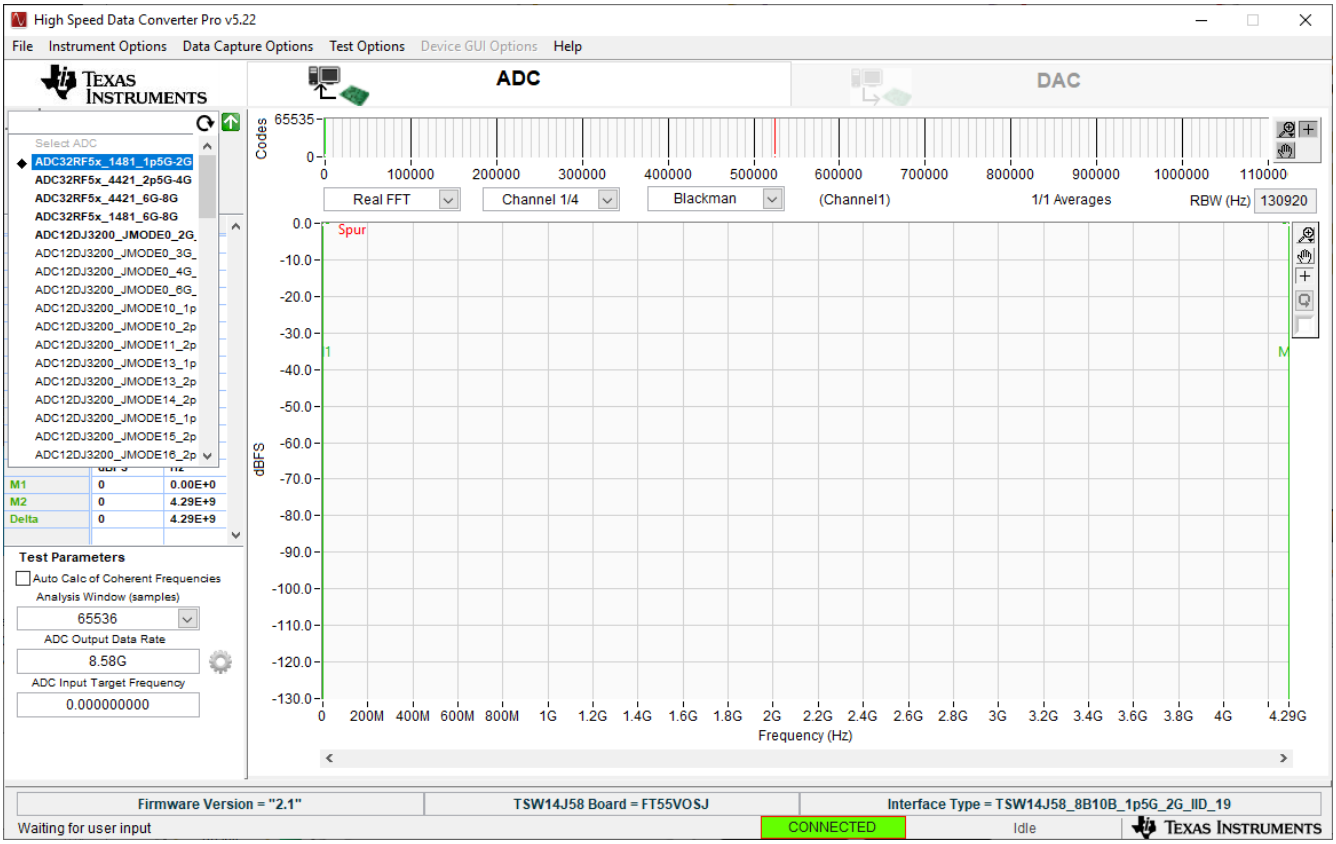


Figure 3-11. ADC32RF5x_1481_1p5G-2G INI file

11. Update the firmware by pressing *Yes* on the pop-up window and waiting for the *Downloading Firmware* message to finish.
12. Open the Additional Device Parameters menu by clicking on the gear next to the ADC Output Data Rate field.
13. Check the box labeled *Enable?* and then enter the parameters shown in Figure 3-12.

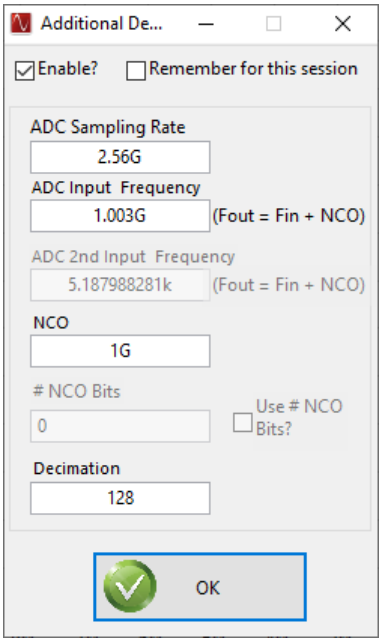


Figure 3-12. Additional Device Parameters , 128x Complex Decimation

14. Once completed, press *OK*.

15. Check the box labeled *Auto Calculation of Coherent Frequencies* to see the *ADC Input Target Frequency* change from 1.003G to the coherent frequency. Set the signal generator connected to the channel B input to this coherent frequency.
16. Change the view window from *Real FFT* to *Complex FFT* and select channel 3/4.
17. Press the *Capture* button and a screen similar to Figure 3-13 shows.
18. Adjust signal generator output such that the measured fundamental power in HSDC Pro is at the user's desired level.

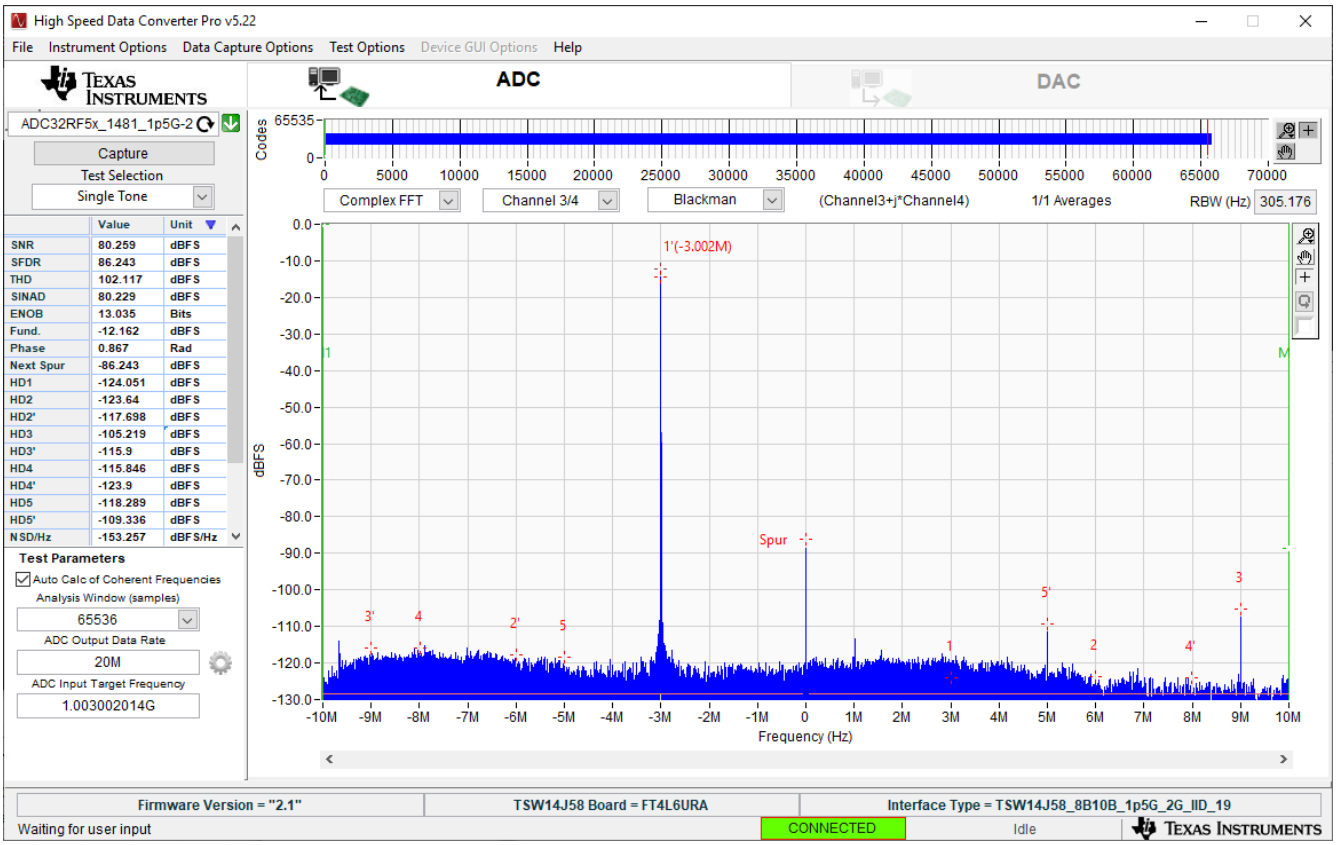


Figure 3-13. 1003.002MHz Input, 128x Complex Decimation, 2x Averaging, Dither Amplitude 3

3.6 Operating Modes

This section covers the available operating modes available to users on the TRF1305-ADC32RFEVM.

CONFIGURATION	AVERAGING MODE	USABLE CHANNELS
Dual without averaging	1x	CHA, CHB
Dual with averaging	2x	CHA, CHB
	4x	CHA, CHB
Quad without averaging	1x	CHA, CHB
Quad with averaging	2x	CHA, CHB

3.6.1 Input Comparison

The TRF1305-ADC32RFEVM features two common configurations when driving an ADC. On channel B, the configuration is optimized for power consumption, featuring a single TRF1305 RF Amplifier driving the ADC. When enabling averaging, the ADC noise spectral density (NSD) decreases with each averaging setting used. The analog input path in this configuration then comes to dominate the NSD at 4x averaging mode. This is because the noise due to the ADC decreases below the noise due to the single TRF1305.

To demonstrate the alternate configuration, channel A includes two TRF1305s, which are broken out to separate SMA connectors on the EVM. An external power splitter can be used in this configuration to average out the noise coming from the analog input path, which can improve noise performance when compared to a split after the TRF1305. Alternatively, there are provisions on the board to evaluate the performance of an onboard resistive power divider. This scheme is shown in Figure 3-14.

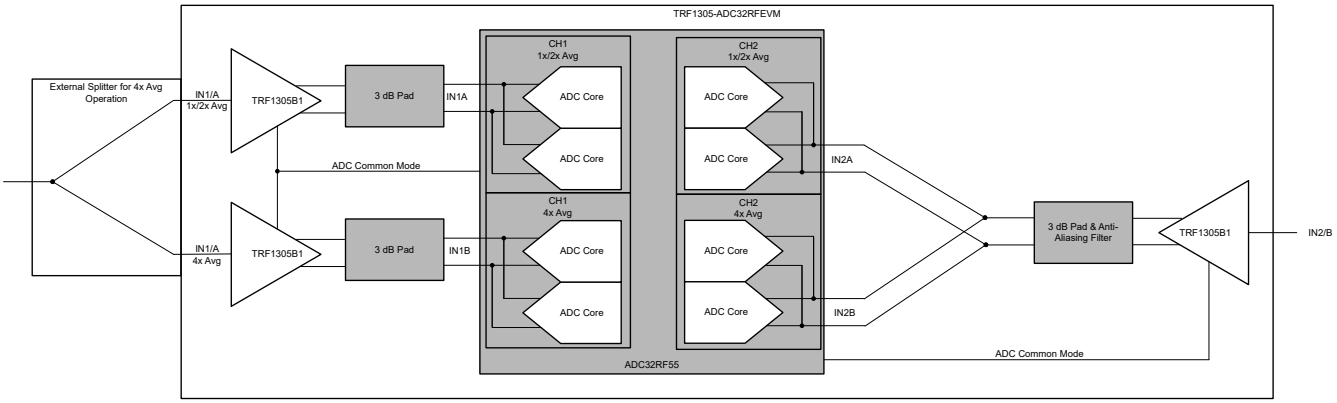


Figure 3-14. Input Comparison

3.6.2 Quad ADC Mode

Programming into quad mode enables the functionality of the channel selection menu in the ADC32RF5xEVM GUI. This programming mode **must** be chosen when the user wants to capture using the inner inputs (INA2, INB2) in **1x** or **2x** averaging modes.

Note

Programming the TRF1305-ADC32RFEVM into *Quad ADC* mode does not allow capture from 4 independent channels simultaneously as this is a dual channel ADC. When configured in this mode, the user can independently select the inputs for channel A and channel B.

4 Hardware Design Files

4.1 Schematics

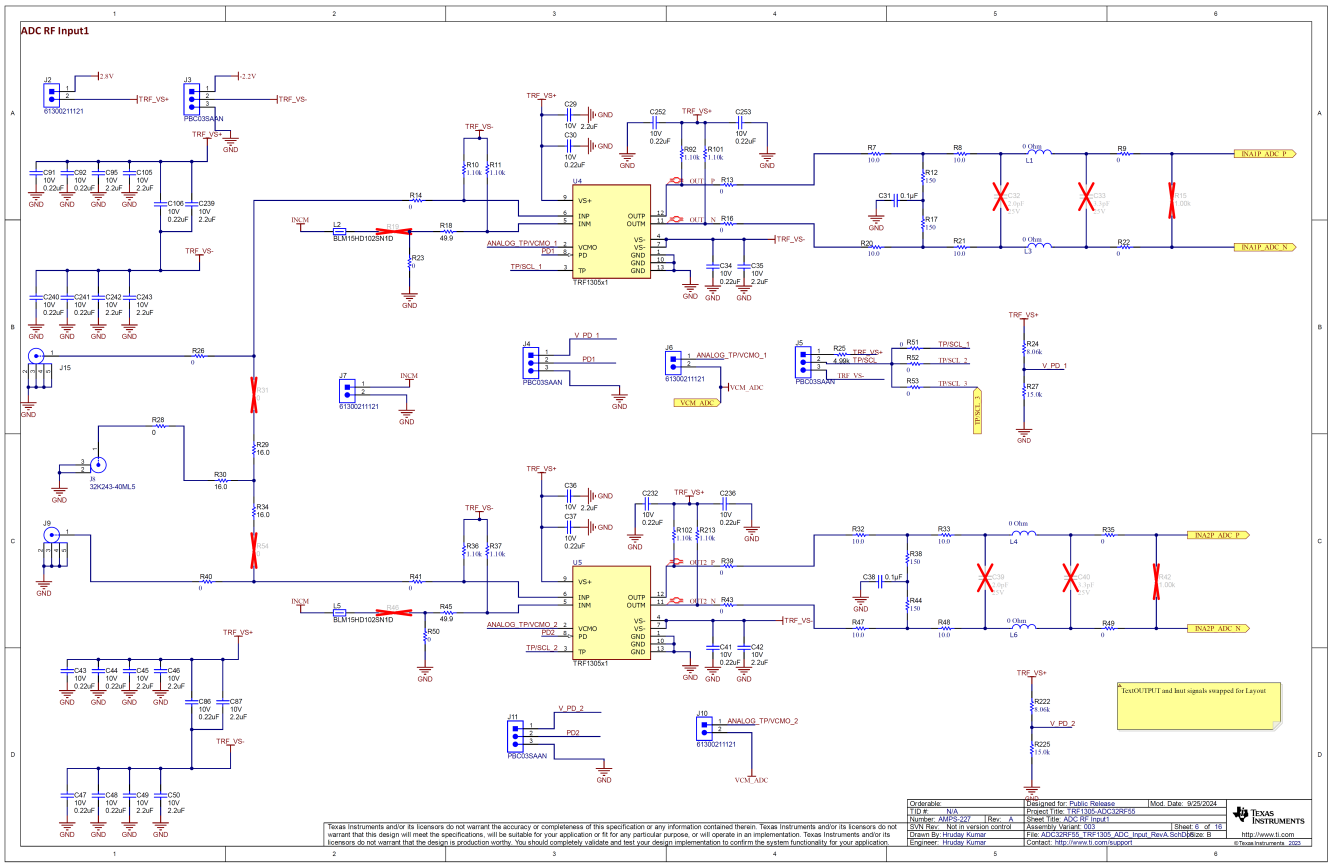


Figure 4-1. Channel A Input Schematic

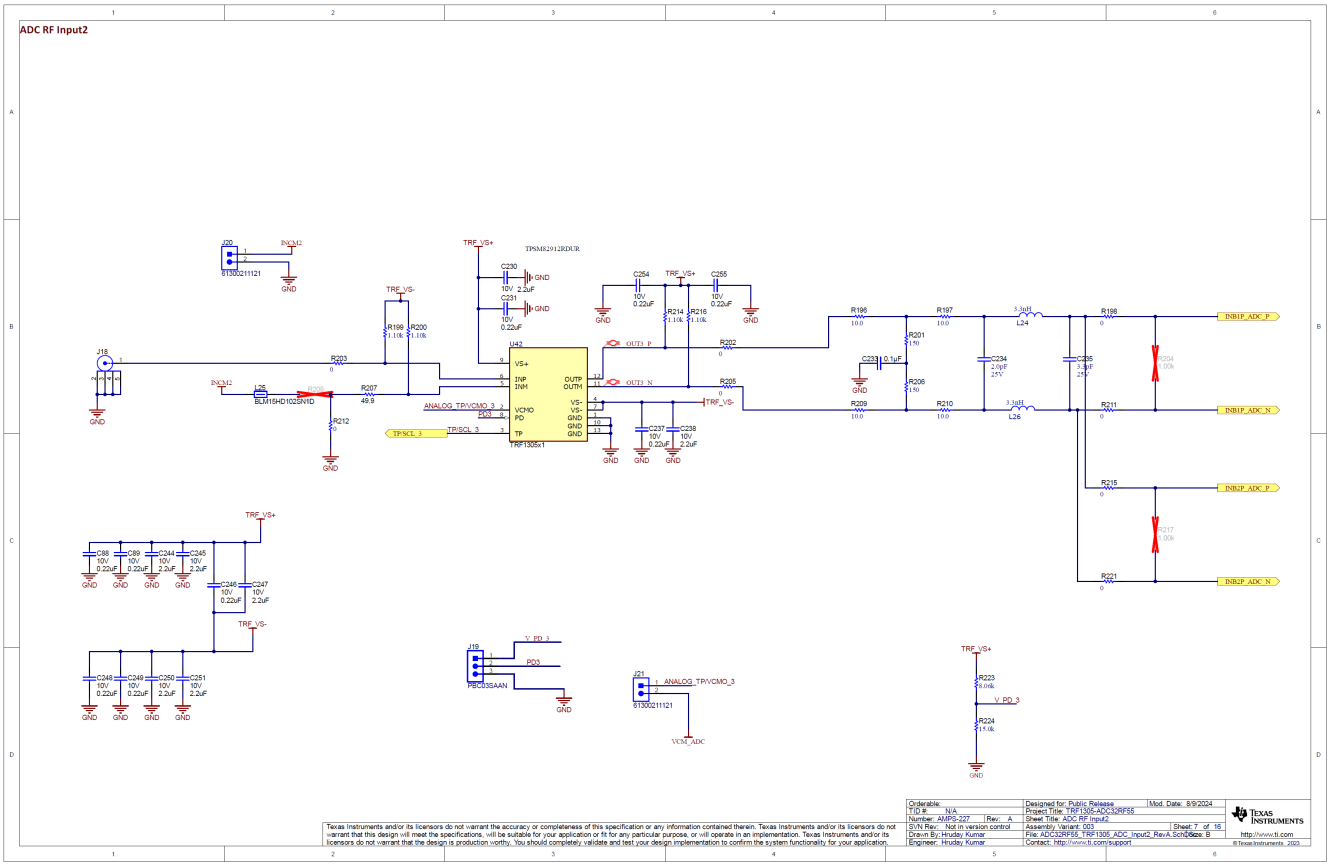


Figure 4-2. Channel B Input Schematic

4.2 PCB Layouts

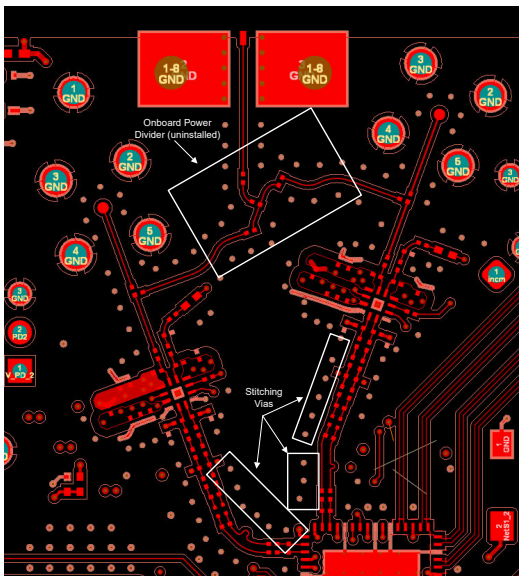


Figure 4-3. Channel A RF Layout

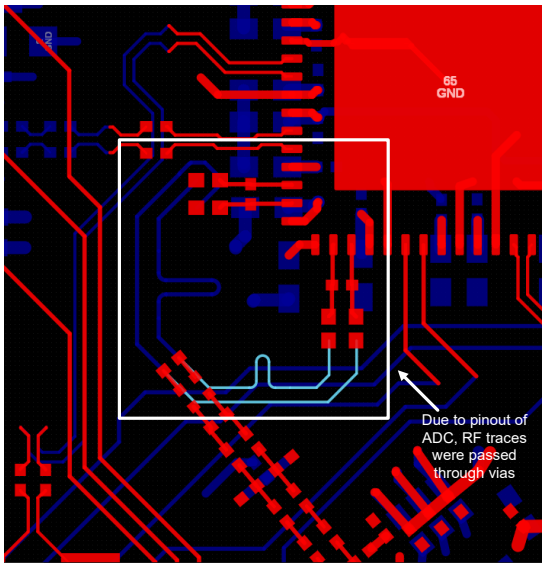


Figure 4-4. Channel B RF Layout

Exemplified in this EVM are common best practices when laying out an RF PCB. Included in this design are stitching vias located to connect the top ground plane to the ground plane directly adjacent. This allows the transmission line created by the RF trace to present a constant impedance as possible.

In general, if possible, avoid passing RF traces through vias to different layers. However, in some cases, like this one, this is necessary as the pinout of the TRF1305 and the ADC CHB are reversed requiring routing through the bottom layer and the middle layer of the PCB, as seen in Figure 4-4. Additional losses are avoided here by utilizing stitching vias and controlled lengths.

Additionally, seen on CHA top layer is the onboard resistive power divider, which is uninstalled as default. Utilization of the onboard resistive divider allows the user to evaluate the pros and cons of incorporating such a divider into the end equipments.

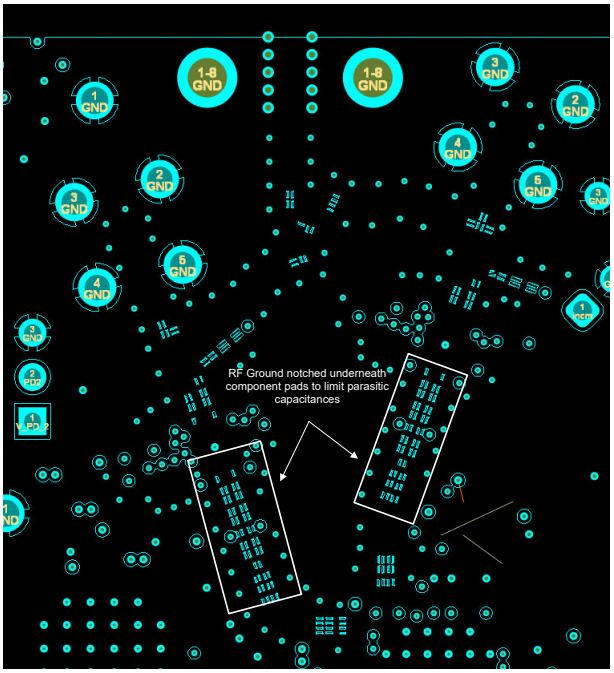


Figure 4-5. RF Ground Layer

The RF ground layer has been notched underneath each of the component pads to present as little excess capacitance to the transmission line above as possible. Other than this, the ground layer has been laid out to be as contiguous as possible to limit excess inductance.

Layer	Info	Thickness
	Top side solder mask	0.4mils
TOP		0.5OZ+Plating to 1OZ
	M6 PP 1080*1 3 mil	
L2		0.5OZ
	370HR Core 10.4mil	
L3		0.5OZ
	370HR PP 7.8 mil	
L4		0.5OZ
	370HR Core 12mil	
L5		0.5OZ
	370HR PP 7.8 mil	
L6		0.5OZ
	370HR Core 10.4mil	
L7		0.5OZ
	M6 PP 1080*1 3 mil	
Bot		0.5OZ+Plating to 1OZ
	Bottom side solder mask	0.4mils

Figure 4-6. Board Stackup

The dielectric in this case was chosen as Panasonic Megtron6. This dielectric was chosen for the controlled dielectric constant. The effects of this are constant and controlled impedance of the surrounding RF traces.

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C27, C28, C31, C38, C51, C52, C61, C62, C68, C69, C70, C71, C72, C73, C75, C76, C77, C83, C84, C85, C90, C94, C102, C103, C104, C107, C108, C109, C110, C112, C211, C212, C213, C214, C216, C217, C219, C221, C224, C225, C226, C227, C228, C229, C233	70	0.1uF	CAP, CERM, 0.1µF, 16V,+/- 10%, X7R, 0201	0201BB104KW160	Passive Plus	0201
C26, C53, C54, C55, C56, C57, C58, C59, C60, C63, C64, C65, C66, C67, C74, C78, C79, C80, C81, C82	20	10uF	CAP, CERM, 10µF, 10V,+/- 20%, X5R, 0402	CL05A106MP8NUB8	Samsung Electro-Mechanics	0402
C29, C35, C36, C42, C45, C46, C49, C50, C87, C95, C105, C230, C238, C239, C242, C243, C244, C245, C247, C250, C251	21	2.2uF	CAP, CERM, 2.2uF, 10V, +/- 10%, X7S, 0402	C1005X7S1A225K050BC	TDK	0402

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
C30, C34, C37, C41, C43, C44, C47, C48, C86, C88, C89, C91, C92, C106, C231, C232, C236, C237, C240, C241, C246, C248, C249, C252, C253, C254, C255	27	0.22uF	CAP, CERM, 0.22uF, 10V, +/- 20%, X5R, 0201	LMK063BJ224MP-F	Taiyo Yuden	0201
C93, C96, C97, C98, C99, C100, C101, C180	8	1uF	CAP, CERM, 1uF, 6.3V,+/- 10%, X7R, 0402	GRM155R70J105KA12D	MuRata	0402
C111	1	10uF	CAP, CERM, 10uF, 10V, +/- 20%, X7R, 0603	GRM188Z71A106MA73D	MuRata	0603
C113, C114, C115	3	1uF	CAP, CERM, 1uF, 50V, +/- 10%, X7R, 0805	C0805C105K5RAC7800	Kemet	0805
C116, C117	2	1000pF	CAP, CERM, 1000pF, 25V, +/- 10%, X7R, 0201	GRM033R71E102KA01D	MuRata	0201
C118	1	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 10%, X7R, 0603	CGA3E2X7R1E104K080DA	TDK	0603
C119	1	1uF	CAP, CERM, 1uF, 10V, +/- 10%, X7R, 0603	0603ZC105KAT2A	Kyocera AVX	0603
C120, C132, C133, C146, C161, C189, C190	7		10µF ±10% 25V Ceramic Capacitor X7S 0805 (2012 Metric)	C2012X7S1E106K125AC	TDK	0805
C121, C134, C135, C147, C162, C191	6	2200pF	CAP, CERM, 2200pF, 50V, +/- 10%, X7R, 0402	GRM155R71H222KA01D	MuRata	0402
C122, C123, C124, C125, C136, C137, C138, C139, C148, C149, C150, C151, C163, C164, C165, C166, C183, C184, C185, C186, C187	21	22uF	CAP, CERM, 22uF, 10V, +/- 20%, X7S, 0805	C2012X7S1A226M125AC	TDK	0805
C126, C129, C141, C159, C177	5	10µF	10µF ±20% 6.3V Ceramic Capacitor X6S 0402 (1005 Metric)	ZRB15XC80J106ME05D	Murata	0402
C127, C130, C142, C156, C178	5	0.1uF	CAP, CERM, 0.1µF, 10V,+/- 10%, X5R, 0201	GRM033R61A104KE84D	MuRata	0201
C128	1	0.47uF	CAP, CERM, 0.47µF, 16V,+/- 10%, X7S, 0402	CGA2B1X7S1C474K050BE	TDK	0402

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
C131	1	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 10%, X5R, 0201	GRM033R61E104KE14J	MuRata	0201
C140, C154, C175, C176	4	1µF	Ceramic Capacitor General Use 1uF ±20% 25V X5R 0402	TMK105BJ105MV-F	Taiyo Yuden	0402
C143	1	2.2µF	Ceramic Capacitor General Use 2.2uF ±20% 16V X5R 0402	EMK105ABJ225MV-F	Taiyo Yuden	0402
C144, C145, C152, C160, C181, C182	6	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 10%, X5R, 0402	GRM155R61E104KA87D	MuRata	0402
C153, C193, C204	3	10uF	CAP, CERM, 10µF, 10V,+/- 10%, X5R, 0603	GRM188R61A106KE69D	MuRata	0603
C155, C170	2	10µF	10µF ±20% 6.3V Ceramic Capacitor X6S 0402 (1005 Metric)	C0402X6S6R3-106MNP	Venkel	0402
C157	1	2.2uF	CAP, CERM, 2.2µF, 16V,+/- 20%, X6S, AEC-Q200 Grade 2, 0402	GRT155C81C225ME13D	MuRata	0402
C158, C173, C196	3	4.7uF	CAP, CERM, 4.7uF, 10V, +/- 10%, X5R, 0402	C1005X5R1A475K050BC	TDK	0402
C167, C174	2	0.1uF	CAP, CERM, 0.1uF, 6.3V, +/- 10%, X5R, 0402	C1005X5R1E104K050BC	TDK	0402
C168, C179	2		10µF ±10% 10V Ceramic Capacitor X5R 0603 (1608 Metric)	C1608X5R1A106K080AC	TDK	0603
C169, C194	2	1uF	CAP, CERM, 1µF, 25V,+/- 20%, X5R, 0402	GRM155R61E105MA12D	MuRata	0402
C171, C195	2	0.1uF	CAP, CERM, 0.1µF, 10V,+/- 10%, X5R, 0201	GRM033R61A104KE15D	MuRata	0201
C172	1	2.2uF	CAP, CERM, 2.2uF, 16V, +/- 10%, X6S, 0402	C1005X6S1C225K050BC	TDK	0402
C188	1	0.1uF	CAP, CERM, 0.1uF, 6.3V, +/- 20%, X5R, 01005	GRM022R60J104ME15L	MuRata	01005
C192	1	10µF	Cap Ceramic 10uF 6.3V X6S 20% Pad SMD 0402 105C T/R	GRM155C80J106ME11D	Murata	0402
C197	1	0.47uF	CAP, CERM, 0.47uF, 10V, +/- 10%, X5R, 0402	GRM155R61A474KE15D	MuRata	0402
C198	1	47uF	CAP, CERM, 47µF, 16V,+/- 10%, X5R, 1210	CL32A476KOJNNNE	Samsung Micro-Electronics	1210
C199	1	2.2uF	CAP, CERM, 2.2uF, 16V, +/- 10%, X5R, 0603	0603YD225KAT2A	Kyocera AVX	0603
C200, C203	2	22µF	22µF ±20% 35V Ceramic Capacitor X5R 0805 (2012 Metric)	GMC21X5R226M35NT	Cal-Chip Electronics	0805
C205	1	0.01uF	CAP, CERM, 0.01µF, 25V,+/- 10%, X7R, 0201	GRM033R71E103KE14D	MuRata	0201
C206	1	1uF	CAP, CERM, 1uF, 25V, +/- 10%, X5R, 0402	GRM155R61E105KA12D	MuRata	0402

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
C207	1	0.015uF	CAP, CERM, 0.015uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	CGA2B3X7R1H153K050BB	TDK	0402
C208, C209	2	10uF	CAP, CERM, 10uF, 25V, +/- 10%, X5R, 0805	TMK212BBJ106KG-T	Taiyo Yuden	0805
C210	1	0.22uF	CAP, CERM, 0.22µF, 16V,+/- 10%, X7R, AEC-Q200 Grade 1, 0402	GCM155R71C224KE02D	MuRata	0402
C215	1	3.3uF	CAP, CERM, 3.3uF, 25V, +/- 10%, X5R, 0603	GMC10X5R335K25NT	Cal-Chip Electronics	0603
C218, C220	2	4.7uF	CAP, CERM, 4.7uF, 16V,+/- 10%, X7R, 0603	GRM188Z71C475KE21D	MuRata	0603
C222, C223	2	18pF	CAP, CERM, 18pF, 50V, +/- 5%, C0G/NP0, 0402	CGA2B2C0G1H180J050EA	TDK	0402
C234	1	2.0pF	CAP, CERM, 3.9pF, 25V,+/- 2.5%, C0G, 0201	02013J2R0ABSTR	Kyocera AVX	0201
C235	1	3.3pF	CAP, CERM, 3.9pF, 25V,+/- 2.5%, C0G, 0201	02013J3R3ABSTR	Kyocera AVX	0201
D1, D4	2	Red	LED, Red, SMD	LTST-C170KRKT	Lite-On	Red 0805 LED
D2	1	15V	Diode, TVS, Bi, 15V, 24.4Vc, SMB	SMBJ15CA-13-F	Diodes Incorporated	SMB
D3	1	30V	Diode, Schottky, 30V, 1A, SOD-123	MBR130T1G	ON Semiconductor	SOD-123
FB1, FB2, FB3, FB4, FB5, FB6, FB7, FB8, FB10	9		30 Ohms @ 100MHz 1 Power Line Ferrite Bead 0603 (1608 Metric) 5A 10mOhm	MPZ1608S300ATAH0	TDK	0603
FB9	1		Bead inductor BLE series, 8A	BLE18PS080SN1D	Murata	0603
FC1, FC2, FC3, FC4, FC5, FC6, FC7	7	27 uF	FILTER LC HIGH FREQ 27uF 1206	NFM31PC276B0J3L	MuRata	3.2x1.6mm
FID1, FID2, FID3, FID4, FID5, FID6	6		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
H1, H2, H5, H6	4		MACHINE SCREW PAN PHILLIPS 4-40	PMSSS 440 0025 PH	B&F Fastener Supply	Machine Screw, 4-40, 1/4 inch
H3, H4, H7, H8	4			2116-440-AL	RAF Electronic Hardware	STANDOFF_HEX_1-4
J1, J9, J15, J18	4		Connector, SMA,Vertical, Thru hole w/SMT center pin	SASF546-P26-X1	Lighthorse Technologies	6.35x12.52x6.35mm
J2, J6, J7, J10, J20, J21	6		Header, 2.54mm, 2x1, Gold, TH	61300211121	Wurth Elektronik	Header, 2.54mm, 2x1, TH
J3, J4, J5, J11, J19	5		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	Sullins Connector Solutions	PBC03SAAN

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
J8	1		SMA JACK 50 OHM, R/A, SMT	32K243-40ML5	Rosenberger	SMA JACK, R/A, SMT
J12	1		Connector, 1.27mm, 40x10, Black, SMT	ASP-134488-01	Samtec	Connector, 1.27mm, 40x10, SMT
J13	1		Header, 100mil, 2x1, Gold, TH	5-146261-1	TE Connectivity	Header, 2x1, 100mil
J14	1		Header, 100mil, 3x2, Gold, TH	PBC03DAAN	Sullins Connector Solutions	Sullins 100mil, 2x3, 230 mil above insulator
J16	1		Power Jack, mini, 2.1mm OD, R/A, TH	RAPC722X	Switchcraft	Jack, 14.5x11x9mm
J17	1		Connector, Receptacle, Mini-USB Type B, R/A, Top Mount SMT	1734035-2	TE Connectivity	USB Mini Type B
L1, L3, L4, L6	4	0 Ohm	0 Ohm Jumper	ERJ-1GN0R00C	Panasonic	0201
L2, L5, L25	3	1000 ohm	Ferrite Bead, 1000 ohm at 100MHz, 0.25A, 0402	BLM15HD102SN1D	MuRata	0402
L9, L10, L11, L12, L13, L14, L15, L16, L17, L18, L22, L23	12	120 ohm	Ferrite Bead, 120 ohm at 100MHz, 0.5A, 0402	74279271	Wurth Elektronik	0402
L19	1	1.5uH	Inductor, 1.5uH, 3.1A, 0.054 ohm, SMD	VCTA32251B-1R5MS6	Cyntec	3.2x2.5x1.2mm
L20	1	2.2µH	Inductor Power Shielded Wirewound 2.2uH 20% 1MHz Composite 8.7A 15mOhm DCR Automotive T/R	XGL4030-222MEC	Coilcraft	SMT_IND_4MM0_4MM0
L21	1	4.7uH	Inductor, Shielded, Ferrite, 4.7uH, 3.5A, 0.031 ohm, SMD	CLF7045NIT-4R7N-D	TDK	Inductor, 7.3x3.2x6.8mm
L24, L26	2	3.3nH	RF Inductors - SMD 1005 1.2nH Unshld 5% 740mA 90mOhms AECQ2	0201DS-3N3XJEW	Coilcraft	0201
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady	PCB Label 0.650 x 0.200 inch
Q1	1	20V	MOSFET, N-CH, 20V, 10A, DQK0006C (WSON-6)	CSD15571Q2	Texas Instruments	DQK0006C

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
R1, R66, R67, R69, R70, R71, R72, R75, R76, R77, R78, R79, R81, R82, R89, R90, R91, R109, R110, R170, R175, R176, R180, R181, R182, R183, R184, R192, R193, R194	30	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	RC0201FR-0710KL	Yageo America	0201
R2, R28, R40, R26, R55, R56, R57, R58, R60, R61, R62, R93, R94, R97, R98, R104, R105, R174	18	0	RES, 0, 5%, 0.05 W, 0201	CRCW02010000Z0ED	Vishay-Dale	0201
R3, R4, R5, R29, R30, R34	6	16	RES, 16.0, 1%, 0.05 W, 0201	RC0201FR-0716RL	Yageo America	0201
R7, R8, R20, R21, R32, R33, R47, R48, R168, R169, R196, R197, R209, R210	14	10	RES, 10.0, 1%, 0.05 W, 0201	RC0201FR-0710RL	Yageo America	0201
R9, R13, R14, R16, R22, R23, R35, R39, R41, R43, R49, R50, R51, R52, R53, R159, R198, R202, R203, R205, R211, R212, R215, R221	24	0	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	ERJ-1GN0R00C	Panasonic	0201
R10, R11, R36, R37, R92, R101, R102, R199, R200, R213, R214, R216	12	1.10k	RES, 1.10 k, 1%, 0.05 W, 0201	RC0201FR-071K1L	Yageo America	0201
R12, R17, R38, R44, R201, R206	6	150	RES, 150, 1%, 0.05 W, 0201	RC0201FR-07150RL	Yageo America	0201
R18, R45, R207	3	49.9	RES, 49.9, 1%, 0.05 W, AEC-Q200 Grade 1, 0201	ERJ-1GNF49R9C	Panasonic	0201

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
R24, R143, R222, R223	4	8.06k	RES, 8.06 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04028K06FKED	Vishay-Dale	0402
R25	1	4.99k	RES, 4.99 k, 1%, 0.063 W, 0402	RC0402FR-074K99L	Yageo America	0402
R27, R224, R225	3	15.0k	RES, 15.0 k, 1%, 0.063 W, 0402	CRCW040215K0FKED	Vishay-Dale	0402
R63, R68, R73, R74, R103, R108, R167, R171, R179, R186, R188, R191	12	100	RES, 100, 1%, 0.05 W, 0201	RC0201FR-07100RL	Yageo America	0201
R84, R86, R88	3	0	RES, 0, 0%, 0.2 W, AEC-Q200 Grade 0, 0402	CRCW04020000Z0EDHP	Vishay-Dale	0402
R95, R96, R99, R100, R106, R107	6	120	RES, 120, 1%, 0.05 W, 0201	RC0201FR-07120RL	Yageo America	0201
R111	1	1.0Meg	RES, 1.0M, 5%, 0.05W, 0201	RC0201JR-071ML	Yageo America	0201
R112, R185	2	2.20k	RES, 2.20 k, 1%, 0.05 W, 0201	RC0201FR-072K2L	Yageo America	0201
R113	1	45.3k	RES, 45.3 k, 1%, 0.05 W, 0201	RC0201FR-0745K3L	Yageo America	0201
R115, R121	2	4.70k	RES, 4.70 k, 1%, 0.1 W, 0402	ERJ-2RKF4701X	Panasonic	0402
R116	1	15.4k	RES, 15.4 k, 0.1%, 0.1 W, 0603	RT0603BRD0715K4L	Yageo America	0603
R118, R132	2	80.6k	RES, 80.6 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040280K6FKED	Vishay-Dale	0402
R119, R136, R158	3	4.87k	RES, 4.87 k, 0.1%, 0.062 W, AEC-Q200 Grade 0, 0402	ERA-2AEB4871X	Panasonic	0402
R120, R149, R155	3	22.1k	RES, 22.1 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040222K1FKED	Vishay-Dale	0402
R122, R129, R138, R146	4	0.002	Chip Resistor 2 mOhms ±1% 0.33W 0603 (1608 Metric) Automotive AEC-Q200	CSS0603FT2L00	Stackpole Electronics	0603 (1608 Metric)
R123	1	1.40k	RES, 1.40 k, 1%, 0.1 W, 0402	ERJ-2RKF1401X	Panasonic	0402
R125, R145	2	4.87k	RES, 4.87 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04024K87FKED	Vishay-Dale	0402
R126	1	17.4k	RES, 17.4 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040217K4FKED	Vishay-Dale	0402
R127	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0402	ERJ-2RKF1001X	Panasonic	0402
R130	1	0uΩ	0 Ohms Jumper 0.1W, 1/10W Chip Resistor 0402 (1005 Metric) - Thick Film	CR0402-10W-000T	Venkel	0402

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
R131	1	11.8k	RES, 11.8 k, 0.1%, 0.1 W, 0603	RT0603BRD0711K8L	Yageo America	0603
R133	1	88.7k	RES, 88.7 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040288K7FKED	Vishay-Dale	0402
R134, R135, R144	3	12.4k	RES, 12.4 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040212K4FKED	Vishay-Dale	0402
R139, R150, R160, R226	4	0	0 Ohms Jumper Chip Resistor 0402 (1005 Metric) Automotive AEC-Q200 Thick Film	ERJ-2GE0R00X	Panasonic	0402
R140	1	7.87k	Res Thick Film 0201 7.87K Ohm 1% 1/20W ±200ppm/°C Molded SMD SMD T/R	ERJ-1GNF7871C	Panasonic	0201
R141	1	80.6k	80.6 kOhms ±1% 0.063W, 1/16W Chip Resistor 0402 (1005 Metric) Thick Film	CRCW040280K6FKEDC	Vishay Dale	0402
R142	1	54.9k	RES, 54.9 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040254K9FKED	Vishay-Dale	0402
R147	1	11.8k	RES, 11.8 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040211K8FKED	Vishay-Dale	0402
R148	1	22.6k	RES, 22.6 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040222K6FKED	Vishay-Dale	0402
R151	1	26.1k	RES, 26.1 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040226K1FKED	Vishay-Dale	0402
R153	1	127k	RES, 127 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	ERJ-2RKF1273X	Panasonic	0402
R154	1	100k	RES, 100 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402100KJNED	Vishay-Dale	0402
R156	1	18.7k	RES, 18.7 k, 0.1%, 0.1 W, 0603	RG1608P-1872-B-T5	Susumu Co Ltd	0603
R157	1	12.4k	12.4 kOhms ±1% 0.1W, 1/10W Chip Resistor 0402 (1005 Metric) Automotive AEC-Q200 Thick Film	ERJ-2RKF1242X	Panasonic	0402
R163	1	422k	RES, 422 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402422KFKED	Vishay-Dale	0402
R164	1	182k	RES, 182 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402182KFKED	Vishay-Dale	0402
R165	1	130k	RES, 130 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402130KJNED	Vishay-Dale	0402

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
R166	1	215k	RES, 215 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402215KFKED	Vishay-Dale	0402
R172	1	12.0k	RES, 12.0 k, 1%, 0.05 W, 0201	RC0201FR-0712KL	Yageo America	0201
R178	1	604	RES, 604, 1%, 0.05 W, 0201	RC0201FR-07604RL	Yageo America	0201
R189, R190	2	2.00k	RES, 2.00 k, 1%, 0.063 W, 0402	CRCW04022K00FKED	Vishay-Dale	0402
S1	1		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	EVQ-5PN04K	Panasonic	6x3.5mm
SW1	1		SWITCH SLIDE SPDT 6A 120V	1101M2S3CGE2	C&K Components	SIP3
T1, T2	2		RF Transformer, 50 Ohm, SMT	TCM2-33WX+	Minicircuits	4.06x4.06x3.81 mm
TP2, TP14, TP15	3		Test Point, Compact, Grey, TH	5123	Keystone	TestPoint, Grey, 220mil, TH
TP4, TP7, TP8	3		Test Point, Multipurpose, Red, TH	5010	Keystone	Red Multipurpose Testpoint
TP5, TP6	2		Test Point, Multipurpose, Black, TH	5011	Keystone	Black Multipurpose Testpoint
TP9, TP10, TP11, TP12, TP13, TP16	6		Test Point, Miniature, Red, TH	5000	Keystone	Red Miniature Testpoint
TP18, TP20	2		Test Point, Miniature, Orange, TH	5003	Keystone Electronics	Orange Miniature Testpoint
U1	1		Nanopower Supervisory Circuits for Automotive, DBV0005A (SOT-23-5)	TPS3836E18QDBVRQ1	Texas Instruments	DBV0005A
U2	1		Dual channel 14-bit 3.0 GSPS RF sampling data converter, RTD0064L (VQFN-64)	ADC32RF55	Texas Instruments	RTD0064L
U3	1		Low-Power Single 2-Input Positive-AND Gate, DRY0006A (USON-6)	SN74AUP1G08DRYR	Texas Instruments	DRY0006A
U4, U5, U42	3		DC to 7.2GHz, 3dB BW, 10dB gain, fully-differential RF amplifier with common-mode control	TRF1305B1RPVR	Texas Instruments	WQFN-FCRLF12
U10	1		64K I2C Smart Serial EEPROM, SOIC-8	24LC65-I/SM	Microchip	SOIC-8, 208mil wide
U11, U12, U14	3		Low-Voltage 4-Bit 1-Of-2 FET Multiplexer/ Demultiplexer, DGV0016A (TVSOP-16)	SN74CBTLV3257DGVR	Texas Instruments	DGV0016A

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
U13, U35, U37	3		4-Bit Dual-Supply Bus Transceiver With Configurable Voltage-Level Shifting and 3-State Outputs, RSV0016A (UQFN-16)	SN74AVC4T774RSVR	Texas Instruments	RSV0016A
U15	1		Ultra Low-Noise JESD204B Compliant Clock Jitter Cleaner With Dual Loop PLLs, NKD0064A (WQFN-64)	LMK04832NKDT	Texas Instruments	NKD0064A
U16	1		12V, 5A, 30mΩ eFuse with Adjustable +/-15% Accurate Current Limit, DRC0010J (VSON-10)	TPS259261DRCR	Texas Instruments	DRC0010J
U17	1		Single Output LDO, 150mA, Fixed 3.3V Output, 2.5 to 24V Input, with Ultra-Low IQ, 5-pin SOT-23 (DBV), -40 to 85 degC, Green (RoHS & no Sb/Br)	TLV70133DBVT	Texas Instruments	DBV0005A
U18, U22, U25	3		3V to 17V, 3A Low Noise and Low Ripple Buck Converter Module with Integrated Ferrite Bead Filter Compensation	TPSM82913RDUR	Texas Instruments	B0QFN28
U19	1		4V to 18V Input, 6A Synchronous SWIFT Step-Down Converter	TPS543620RPYR	Texas Instruments	VQFN-HR14
U20, U21, U28, U29	4		High-Side Measurement, Bi-Directional Current / Power Monitor with I2C Interface, 2.7 to 5.5V, -40 to 125 degC, 10-pin SOP (DGS10), Green (RoHS & no Sb/Br)	INA238AIDGSR		DGS0010A
U23, U26, U31	3		1A, Ultra-Low Noise, Ultra-High PSRR, RF Voltage Regulator	TPS7A9401DSC	Texas Instruments	WSON10
U24	1		500mA, high-PSRR, low-IQ, low-dropout voltage regulator with enable 4-X2SON -40 to 125	TLV755185PDQNR	Texas Instruments	X2SON4
U27	1		Linear Voltage Regulator IC Output 4A 12-VQFN-HR (2.2x2.5)	TPS7A5301RPSR	Texas Instruments	VQFN-HR-12
U30	1		3V to 17V, 3A Micro Noise (20µVRMS) and Micro Ripple (200µVPP) buck converter	TPS62913RPUR	Texas Instruments	VQFN-HR10
U32	1		Buck Switching Regulator IC Negative Adjustable -1V 1 Output 1A 12-WSON Exposed Pad	TPS63710DRRT	Texas Instruments	WSON12

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
U33	1		Vin -3V to -36V, -1A, Ultra-Low-Noise, High-PSRR, Low-Dropout Linear Regulator, RGW0020A (VQFN-20)	TPS7A3301RGWR	Texas Instruments	RGW0020A
U34	1		Quad High Speed USB to Multipurpose UART/ MPSSE IC	FT4232HL-REEL	FTDI	LQFP_10x10mm
U36	1		Low-Power Single Bus Buffer Gate with 3-State Output, DRY0006A (USON-6)	SN74AUP1G126DRYR	Texas Instruments	DRY0006A
U38	1		1K Microwire Compatible Serial EEPROM, TSSOP-8	93LC46B-I/ST	Microchip	TSSOP-8
U39, U40, U41	3		Single Bus Buffer Gate With 3-State Outputs, DCK0005A, LARGE T&R	SN74LVC1G125DCKR	Texas Instruments	DCK0005A
Y1	1		Crystal, 12MHz, 20ppm, SMD	ECS-120-18-23G-JGN-TR	ECS Inc.	6x3.5mm
C32, C39	0	2.0pF	CAP, CERM, 3.9pF, 25V,+/- 2.5%, C0G, 0201	02013J2R0ABSTR	Kyocera AVX	0201
C33, C40	0	3.3pF	CAP, CERM, 3.9pF, 25V,+/- 2.5%, C0G, 0201	02013J3R3ABSTR	Kyocera AVX	0201
C201, C202	0	22µF	22µF ±20% 35V Ceramic Capacitor X5R 0805 (2012 Metric)	GMC21X5R226M35NT	Cal-Chip Electronics	0805
F1	0		Fuse Chip Fast Acting 2.5A 32V SMD Solder Pad 1206 T/R	SF-1206FP250-2	Bourns	1206
R6, R59, R80	0	0	RES, 0, 5%, 0.05 W, 0201	CRCW02010000Z0ED	Vishay-Dale	0201
R15, R42, R204, R217	0	1.00k	RES, 1.00 k, 1%, 0.05 W, 0201	CRCW02011K00FKED	Vishay-Dale	0201
R19, R54, R31, R46, R208	0	0	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	ERJ-1GN0R00C	Panasonic	0201
R64, R65, R177	0	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	RC0201FR-7D10KL	Yageo America	0201
R83, R85, R87, R187, R195	0	0	RES, 0, 0%, 0.2 W, AEC-Q200 Grade 0, 0402	CRCW04020000Z0EDHP	Vishay-Dale	0402
R114	0	4.99k	RES, 4.99 k, 1%, 0.05 W, 0201	RC0201FS-7D4K99L	Yageo America	0201
R117, R124, R128	0	4.70k	RES, 4.70 k, 1%, 0.1 W, 0402	ERJ-2RKF4701X	Panasonic	0402
R137	0	4.70k	RES, 4.70 k, 1%, 0.0625 W, 0402	RC0402FR-074K7L	Yageo America	0402
R152	0	12.1k	RES, 12.1 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	RMCF0402FT12K1	Stackpole Electronics Inc	0402

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
R161	0	10k	10 kOhms 0.25W, 1/4W J Lead Surface Mount Trimmer Potentiometer Cermet 11.0 Turn Side Adjustment	3224J-1-103E	Nidec Component Corporation	SMD4
R162	0	237k	RES, 237 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402237KFKED	Vishay-Dale	0402
R173	0	12.0k	RES, 12.0 k, 1%, 0.05 W, 0201	RC0201FR-7D12KL	Yageo America	0201

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

6 Related Documentation

The following are available documentation and software:

- ADC32RF5xEVM software, available at ADC32RF54EVM tool page
- Texas Instruments, ADC32RF5x Dual Channel 14-bit 2.6 to 3-GSPS RF Sampling Data Converter, data sheet
- Texas Instruments, TRF1305B1 Single-Channel, DC to > 6.5GHz, 3dB-Bandwidth, Fully Differential Amplifier, data sheet
- Texas Instruments, TRF1305B1-D2D Evaluation Module, user's guide
- Texas Instruments, TSW14J58 JESD204C Data Capture and Pattern Generator Card, user's guide
- Texas Instruments, High Speed Data Converter Pro software and (High Speed Data Converter Pro GUI, user's guide

Note

The EVM schematics, layout, and BOM are available on the TRF1305-ADC32RFEVM tool page.

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

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2 *Limited Warranty and Related Remedies/Disclaimers*:

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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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